PATENT ABSTRACTS OF JAPAN

Cited document 3

(11)Publication number : 10-170619
(43)Date of publication of application : 26.06.1998

(51)Int.Cl. G01R 33/09
H01L 43/08

(21)Application number : 08-326720
(22)Date of filing : 06.12.1996

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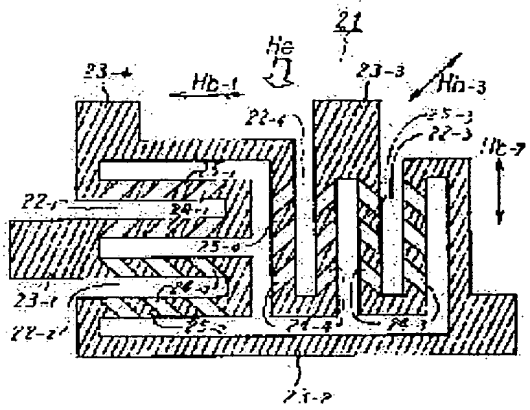
(54) MAGNETIC SENSOR AND ALTERNATING BIAS MAGNETIC FIELD IMPRESSING METHOD THEREFOR

(57)Abstract:
PROBLEM TO BE SOLVED: To accurately measure the direction and intensity of an external magnetic field from the optional direction by impressing an alternating bias magnetic field in the internal magnetization direction of a pair of barber pole type magnetic resistor patterns which are formed by laminating plural conductor layers on a magnetic film pattern and whose internal magnetization directions cross at a right angle to each other.
SOLUTION: A magnetic resistance element 21 is formed by connecting barber pole type magnetic resistor patterns 22-1 to 22-4 in a full bridge shape by connecting terminals 23-1 to 23-4. Patterns 22-1 to 22-2 whose internal magnetization is in the lateral direction are formed on ferromagnetic thin films 24-1 to 24-2 by inclining plural conductor layers 25-1 to 25-2 by 45 degrees in the internal magnetization direction. On the other hand, patterns 22-3 to 22-4 whose internal magnetization is in the vertical direction are formed on ferromagnetic thin films 24-3 and 24-4 by inclining plural conductor layers 25-3 and 25-4 by 45 degrees in the internal magnetization direction. When an external magnetic field He is impressed on a forming surface of these patterns 22-1 to 22-4 in parallel from the optional direction, since a resistance change according to intensity of a magnetic field component in the respective internal magnetization directions is caused, when an operation is performed on its change quantity, the direction and intensity of the external magnetic field He can be known.



LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

* NOTICES *

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CLAIMS

[Claim(s)]
[Claim 1] The magnetometric sensor which the laminating of two or more conductor layers is carried out to a magnetic film pattern, and is characterized by having an alternating-field impression means to impress an alternation bias field in each internal magnetization direction of the magnetic resistance element a magnetic resistance element and the internal magnetization direction cross at right angles, and in which the barbershop pole mold magnetic-reluctance object pattern of a pair was prepared at least, and the magnetic-reluctance object pattern of this pair.
[Claim 2] Are the same as that of the 1st magnetic-substance pattern. the 1st magnetic-reluctance object pattern and internal magnetization direction of a barbershop pole mold -- this -- the inclination of two or more conductor layers by which the laminating was carried out to the magnetic film pattern -- this -- with the 2nd magnetic-reluctance object pattern of the barbershop pole mold which makes 90 degrees to the inclination of the conductor layer of the 1st magnetic-substance pattern the internal magnetization direction -- this -- with the 3rd magnetic-reluctance object pattern of the barbershop pole mold which makes 90 degrees to the internal magnetization direction of the 1st magnetic-reluctance object pattern the internal magnetization direction -- this -- the inclination of two or more conductor layers by which was the same as that of the 3rd magnetic-substance pattern, and the laminating was carried out to the magnetic film pattern -- this -- the 4th magnetic-reluctance object pattern of the barbershop pole mold which makes 90 degrees to the inclination of the conductor layer of the 3rd magnetic-substance pattern the magnetic resistance element connected to the full bridge -- this -- with the 1st alternating-field generating means which impresses an alternation bias field in the internal magnetization direction of the 1st and 2nd magnetic-reluctance object patterns this -- the magnetometric sensor characterized by having the 2nd alternating-field generating means which impresses an alternation bias field in the internal magnetization direction of the 3rd and 4th magnetic-reluctance object patterns.
[Claim 3] Are the same as that of the 1st magnetic-substance pattern. the 1st magnetic-reluctance object pattern and internal magnetization direction of a barbershop pole mold -- this -- the inclination of two or more conductor layers by which the laminating was carried out to the magnetic film pattern -- this -- with the 2nd magnetic-reluctance object pattern of the barbershop pole mold which makes 90 degrees to the inclination of the conductor layer of the 1st magnetic-substance pattern the internal magnetization direction -- this -- with the 3rd magnetic-reluctance object pattern of the barbershop pole mold which makes 90 degrees to the internal magnetization direction of the 1st magnetic-reluctance object pattern the internal magnetization direction -- this -- the inclination of two or more conductor layers by which was the same as that of the 3rd magnetic-substance pattern, and the laminating was carried out to the magnetic film pattern -- this -- the 4th magnetic-reluctance object pattern of the barbershop pole mold which makes 90 degrees to the inclination of the conductor layer of the 3rd magnetic-substance pattern the magnetic resistance element connected to the full bridge, and this the 1- the magnetometric sensor characterized by having an alternating-field generating means to impress an alternation bias field in the direction of about 45 degrees to the internal magnetization direction of the 4th magnetic-reluctance object pattern.
[Claim 4] Claims 1 or 2 characterized by being the coil which said alternating-field generating means wound around the package which contained said magnetic resistance element, or a magnetometric sensor given in three.
[Claim 5] Claims 1 or 2 characterized by said alternating-field generating means being the coil which formed the conductor pattern in the shape of a spiral on the insulating substrate, or a magnetometric

sensor given in three.
[Claim 6] The magnetometric sensor according to claim 4 or 5 characterized by said coil and magnetic resistance element, and a package carrying out a laminating, and coming to form them on an insulating substrate.
[Claim 7] The alternation bias field impression approach of the magnetometric sensor characterized by establishing zero field time amount for every change of the direction of a field on the occasion of impression of said alternation bias field in a magnetometric sensor according to claim 1 to 3.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the impression approach of the alternation bias field in the magnetometric sensor which enabled measurement of a minute field, and its magnetometric sensor.

[0002] If the direction and strength of a field with feeble earth magnetism level can measure correctly, earth magnetism or the field from a magnet can be measured, bearing, distance, etc. of the location on which the sensor is put can be determined, and it can apply to extensive applications, such as a bearing sensor and a pointing device.
[0003]
[Description of the Prior Art] The explanatory view of the conventional magnetic direction sensor by which drawing 10 used the magnetic film, and drawing 11 are the explanatory views of the resistance law in the magnetic direction sensor of drawing 10 .
[0004] the long and slender magnetic-reluctance pattern 2 which consists of a ferromagnetic thin film on the substrate with which the magnetic sensing element 1 used for a magnetic direction sensor becomes in Si etc. in drawing 10 -- the shape of a clinch -- forming -- the both ends -- a conductor -- it comes to form a terminal 3
[0005] The alternation bias field Hb is impressed to the magnetic sensing element 1 which detects the external magnetic field helium which intersects perpendicularly in the die-length direction (internal magnetization) of the magnetic-reluctance pattern 2 in the crossover (it intersects perpendicularly desirably) direction to the die-length direction of the magnetic-reluctance pattern 2.
[0006] In this magnetic sensing element 1, when the external magnetic field helium of the rectangular direction is impressed to the internal magnetization M of the magnetic-reluctance pattern 2 which supplied the predetermined current for actuation, as the resistance law is shown in drawing 11 which set to variation deltaR of magnetic reluctance the axis of ordinate which passes an axis of abscissa along the zero of magnetic field strength H and an axis of abscissa, a resistance law 4 is the Yamagata configuration which set the symmetry axis as the axis of ordinate.
[0007] Then, when an external magnetic field helium is given to the magnetic sensing element 1 to which the alternation bias field Hb and the actuation current i were impressed, the field change to plus bias serves as Hb->Hb+helium, and the field change to minus bias serves as -Hb->-Hb+helium.
[0008] Therefore, if resistance change accompanying the field change to plus bias is set to delta-1 and resistance change accompanying the field change to minus bias is set to delta-2, the resistance variation (output) delta in the sensor using the magnetic sensing element 1 will serve as delta=delta -1+delta-2.
[0009]
[Problem(s) to be Solved by the Invention] In the conventional magnetometric sensor with the resistance law shown in drawing 10 , as explained above, since an external magnetic field helium was detected as a changed part from the alternation bias field Hb, when the values of the bias field Hb differed, output values may differ to the same external magnetic field helium, and it had the trouble that exact measurement could not be performed.
[0010] On the other hand, the field sensor (for example, JP,4-191685,A) which impresses an alternation bias field in the internal magnetization and this direction of the component is known using the barbershop pole mold magnetic resistance element.
[0011] Drawing 12 is the informality top view of the conventional magnetic resistance element for field

sensors which impresses an alternation bias field in the internal magnetization direction. A magnetic resistance element 5 As an arrow head shows, four barbershop pole mold magnetic-reluctance object patterns 6-1 to 6-4 which arranged the direction of internal magnetization M with the longitudinal direction (left) of a Fig. are formed, and those magnetic-reluctance object patterns 6-1 to 6-4 are connected to the full bridge through the connection terminal 7-1 to 7-4.

[0012] When the alternation bias field Hb of a predetermined actuation current (i), and the internal magnetization M and this direction is impressed to this magnetic resistance element 5, it is not concerned with the value of the bias field Hb, but an external magnetic field helium can be measured correctly.

[0013] However, the external magnetic fields helium measured by the magnetic resistance element 5 are parallel and a configuration which measures correctly the external magnetic field helium of the direction of a right angle to the internal magnetization M, and the trouble that the direction and magnetic field strength cannot be measured to the external magnetic field helium from arbitration is in the forming face of the magnetic-reluctance object pattern 6-1 to 6-4.

[0014]

[Means for Solving the Problem] Drawing 1 is a barbershop pole mold magnetic-reluctance object pattern and the explanatory view of the resistance law. In the band-like magnetic-reluctance object pattern 11 with which the ferromagnetic pattern 12 was formed, it is whenever [tilt-angle / of 45 degrees], and the laminating of two or more conductor layers 13 at equal intervals was carried out to the die-length direction (the direction of internal magnetization M) The internal magnetization M tends to turn to the die-length direction of the ferromagnetic pattern 12, and in the condition that there is especially no external magnetic field, the internal magnetization M has become leftward, as shown in the (a) Fig., and shown in the facing-the-right or (b) Fig.

[0015] and -- magnetic reluctance -- the body -- a pattern -- 11 -- the cross direction -- namely, -- the interior -- magnetization -- M -- a right angle -- a direction -- an external magnetic field -- helium -- having impressed -- a case -- magnetic reluctance -- the body -- a pattern -- 11 -- a resistance law -- an axis of ordinate -- magnetic reluctance -- variation -- delta -- R -- delta -- R -- = -- zero -- passing -- an axis of abscissa -- magnetic field strength -- H -- ** -- having carried out -- (-- c --) -- a Fig. -- being shown -- as -- the sense of the internal magnetization M -- an inclination -- reverse -- becoming .

[0016] That is, as shown, for example in drawing 1 (a), the resistance law 14 in case the internal magnetization M is facing the right, and the resistance law 15 as shown in drawing 1 (b), in case the internal magnetization M is facing the left have a reverse inclination, and in order to reverse the internal magnetization M, it turns out that what is necessary is just to impress the field more than Number Oe in the direction which you want to reverse.

[0017] Then, if the output when impressing the external magnetic field helium of the direction of a right angle to the magnetic-reluctance object pattern 11 of drawing 1 (a) at the internal magnetization M is set to A, the output when impressing the same external magnetic field helium to the magnetic-reluctance object pattern 11 of drawing 1 (b) is set to B and the sense of the internal magnetization M is changed facing the right and leftward, the output to an external magnetic field helium will serve as A+B.

[0018] The 1st magnetometric sensor of this invention which uses said property of the magnetic-reluctance object pattern 11, and solves the trouble of the conventional technique is characterized by to have an alternating-field impression means to by_which two or more conductor layers impress an alternation bias field in each internal magnetization direction of the magnetic resistance element with which a laminating is carried out and a magnetic resistance element and the internal magnetization direction cross at right angles and in which the barbershop pole mold magnetic-reluctance object pattern of a pair was prepared at least, and the magnetic-reluctance object pattern of this pair at a magnetic film pattern.

[0019] The 2nd magnetometric sensor of this invention The 1st magnetic-reluctance object pattern of a barbershop pole mold, the internal magnetization direction -- this -- the inclination of two or more conductor layers by which was the same as that of the 1st magnetic-substance pattern, and the laminating was carried out to the magnetic film pattern -- this -- with the 2nd magnetic-reluctance object pattern of the barbershop pole mold which makes 90 degrees to the inclination of the conductor layer of the 1st magnetic-substance pattern the internal magnetization direction -- this -- with the 3rd magnetic-reluctance object pattern of the barbershop pole mold which makes 90 degrees to the internal magnetization direction of the 1st magnetic-reluctance object pattern the internal

magnetization direction -- this -- the inclination of two or more conductor layers by which was the same as that of the 3rd magnetic-substance pattern, and the laminating was carried out to the magnetic film pattern -- this -- the 4th magnetic-reluctance object pattern of the barbershop pole mold which makes 90 degrees to the inclination of the conductor layer of the 3rd magnetic-substance pattern the magnetic resistance element connected to the full bridge -- this -- with the 1st alternating-field generating means which impresses an alternation bias field in the internal magnetization direction of the 1st and 2nd magnetic-reluctance object patterns this -- it is characterized by having the 2nd alternating-field generating means which impresses an alternation bias field in the internal magnetization direction of the 3rd and 4th magnetic-reluctance object patterns.

[0020] The 3rd magnetometric sensor of this invention The 1st magnetic-reluctance object pattern of a barbershop pole mold, the internal magnetization direction -- this -- the inclination of two or more conductor layers by which was the same as that of the 1st magnetic-substance pattern, and the laminating was carried out to the magnetic film pattern -- this -- with the 2nd magnetic-reluctance object pattern of the barbershop pole mold which makes 90 degrees to the inclination of the conductor layer of the 1st magnetic-substance pattern the internal magnetization direction -- this -- with the 3rd magnetic-reluctance object pattern of the barbershop pole mold which makes 90 degrees to the internal magnetization direction of the 1st magnetic-reluctance object pattern the internal magnetization direction -- this -- the inclination of two or more conductor layers by which was the same as that of the 3rd magnetic-substance pattern, and the laminating was carried out to the magnetic film pattern -- this -- the 4th magnetic-reluctance object pattern of the barbershop pole mold which makes 90 degrees to the inclination of the conductor layer of the 3rd magnetic-substance pattern the magnetic resistance element connected to the full bridge, and this the 1- it is characterized by having an alternating-field generating means to impress an alternation bias field in the direction of about 45 degrees to the internal magnetization direction of the 4th magnetic-reluctance object pattern.

[0021] The 4th magnetometric sensor of this invention is the coil which said alternating-field generating means wound around the package which contained said magnetic resistance element in the 1st of said this invention - the 3rd magnetometric sensor.

[0022] The 5th magnetometric sensor of this invention is the coil with which said alternating-field generating means formed the conductor pattern in the shape of a spiral on the insulating substrate in the 1st of said this invention - the 3rd magnetometric sensor.

[0023] In the 4th or 5th magnetometric sensor of said this invention, said coil and magnetic resistance element, and a package carry out the laminating of the 6th magnetometric sensor of this invention on an insulating substrate, and it comes to form it.

[0024] The alternation bias field impression approach in the magnetometric sensor of this invention which uses said property of the magnetic-reluctance object pattern 11, and solves the trouble of the conventional technique is establishing zero field time amount for every change of the direction of a field on the occasion of impression of said alternation bias field in the 1st of said this invention - the 3rd magnetometric sensor.

[0025] The direction of internal magnetization intersects perpendicularly, and even if there are few 1st magnetometric sensors of said this invention, they are equipped with the barbershop pole mold magnetic-reluctance object pattern of a pair, and impress an alternation bias field in each internal magnetization direction of the magnetic-reluctance object pattern.

[0026] Then, impression of the external magnetic field which should be detected by the magnetic-reluctance object pattern of the pair generates the output according to the strength of the internal magnetization direction component of the impressed external magnetic field to the magnetic-reluctance object pattern of a pair. Therefore, the direction and strength of this impressed external magnetic field are made detectable.

[0027] By two pairs of things to do for magnetic-reluctance object pattern full bridge connection, the 2nd and 3rd magnetometric sensors of said this invention can make input voltage common, and can obtain each magnetic-resistance-element output.

[0028] The 4th and 5th magnetometric sensors of said this invention offer an easy and simple alternation bias field generating means. The 6th magnetometric sensor of said this invention is a miniaturization ****** thing about the 4th and 5th magnetometric sensors of this invention.

[0029] When, as for the alternation bias field impression approach of said this invention, a field is impressed, internal magnetization of a magnetic-reluctance object pattern is left with the sense of internal magnetization [a set and after it] at the direction of a bias field component of an impression

field also in the condition of bias field zero gathering in the direction of a bias field component. Consequently, measurement of a much more exact external magnetic field is enabled.

[0030]

[Embodiment of the Invention] The explanatory view of the magnetic resistance element of the magnetometric sensor according [drawing 2] to the example of this invention, the explanatory view of the magnetic detection equipment with which drawing 3 was equipped with the magnetometric sensor by the example of this invention, and drawing 4 are the explanatory views of the alternation bias field impression approach according [drawing 6] to this invention according [the explanatory view of the 1st example of an alternation bias field impression means and drawing 5] to the explanatory view of the 2nd example of an alternation bias field impression means.

[0031] In drawing 2 which carried out simple, as for the magnetic resistance element 21, the barbershop pole mold magnetic-reluctance object pattern 22-1, 22-2, 22-3, and 22-4 are connected to the full bridge configuration through the connection terminal 23-1, 23-2, 23-3, and 23-4.

[0032] Two or more conductor layers 25-1 by which internal magnetization formed the magnetic-reluctance object pattern 22-1 of the longitudinal direction of drawing on the ferromagnetic thin film 24-1 are formed so that it may incline 45 degrees in the direction of the lower left from the upper right of drawing.

[0033] It connects with the magnetic-reluctance object pattern 22-1 through the connection terminal 23-1, and the inclination of two or more conductor layers 25-2 in which the magnetic-reluctance object pattern 22-2 of a direction as the magnetic-reluctance object pattern 22-1 with the same internal magnetization was formed on the ferromagnetic thin film 24-2 is formed so that 45 degrees 25-1, i.e., a conductor layer, and 25-2 may make 90 degrees in the upper left or the direction of the lower right of drawing.

[0034] It connects with the magnetic-reluctance object pattern 22-2 through the connection terminal 23-2, and two or more conductor layers 25-3 by which internal magnetization formed the magnetic-reluctance object pattern 22-3 of the vertical direction of drawing on the ferromagnetic thin film 24-3 are formed so that it may incline 45 degrees in the direction of the lower right from the upper left of drawing.

[0035] It connects with the magnetic-reluctance object pattern 22-3 through the connection terminal 23-3, and the inclination of two or more conductor layers 25-4 in which the magnetic-reluctance object pattern 22-4 of a direction as the magnetic-reluctance object pattern 22-3 with the same internal magnetization was formed on the ferromagnetic thin film 24-4 is formed so that 45 degrees 25-3, i.e., a conductor layer, and 25-4 may make 90 degrees in the direction of the lower left from the upper right of drawing.

[0036] And the magnetic-reluctance object pattern 22-1 and 22-4 are connected through the connection terminal -4, and alternation bias field Hb-2 for external magnetic field detection impressed to the magnetic-reluctance object pattern 22-1 and 22-2 to alternation bias field Hb-1 for external magnetic field detection impressed to the magnetic-reluctance object pattern 22-1 and 22-2 being the longitudinal direction of drawing are the vertical direction of drawing.

[0037] When a ferromagnetic thin film 24-1 to 24-4 is formed in 82%nickel-Fe with a thickness of 500A - 2000A and a conductor layer 25-1 to 25-4 is formed with gold with a thickness of 5000A in this magnetic resistance element 21, If internal magnetic reversal is possible by making the field of number Oe extent impress and the external magnetic field helium parallel and from arbitration is impressed to the forming face of the magnetic-reluctance object pattern 22-1 to 22-4 The resistance change according to the strength of the field component of the direction of each internal magnetization produces the magnetic-reluctance object pattern 22-1 to 22-4, and the direction and reinforcement of an external magnetic field helium can be known by carrying out data processing of the part for the change.

[0038] In addition, alternation bias field Hb-3 of 45 degrees have the component of the direction of M of ****** of the magnetic-reluctance object pattern 22-1 to 22-4 towards the magnetic-reluctance object pattern 22-1, 22-2, 22-3, and internal magnetization of 22-4. Therefore, even if it changes into alternation bias field Hb-1 and Hb-2 and makes it make alternation bias field Hb-3 impress, the direction and reinforcement of an external magnetic field helium can be known.

[0039] In drawing 3 , an actuation current is supplied to the magnetic resistance element 21 of magnetic detection equipment 31 through the connection terminal 23-4 and 23-2 from the drive power source 32. It connects with AC power supply 35 through the resistance Rs for synchronous detection, and the alternating current of predetermined frequency is supplied to the coils 33 and 34 of the pair

which makes an alternation bias field generating means from AC power supply 35, and they impress alternation bias field Hb-1 of a rectangular 2-way, and Hb-2 (refer to drawing 2) to a magnetic resistance element 21.

[0040] The connection terminal 23-1 used as the output terminal of a magnetic resistance element 21 and 23-3 are connected to the alternating current amplifier 36 which makes a resistance detection means through the input-side coupling capacitor C-1 or C-2, an alternating current amplifier 36 is connected to the input terminal 39 of an analog switch 38 through the output side coupling capacitor 37, and the electrical potential difference of the resistance Rs for synchronous detection is amplified and inputted into the control input terminal 40 of an analog switch 38 through the differential amplifier 41.

[0041] The output terminal 42 of an analog switch 38 is connected to the output terminal 44 through RC filter 43 which carries out the component of the passage of the frequency component of an alternation bias field. In drawing 4 (a), the magnetic-reluctance sensor 51 comes to wind the coils 54 and 55 for alternation bias field impression around the magnetic-resistance-element package 53 which held the **** magnetic resistance element 52 which shows an outline to drawing 4 (b).

[0042] In the magnetic resistance element 52 equivalent to the above-mentioned magnetic resistance element 21 The barbershop pole mold magnetic-reluctance object pattern 56 whose internal magnetization is the longitudinal direction of drawing, If the barbershop pole mold magnetic-reluctance object pattern 57 whose internal magnetization is the vertical direction of drawing is formed at least and the magnetic-reluctance object pattern 56 is equivalent to the magnetic-reluctance object pattern 22-1 of a magnetic resistance element 21, or 22-2 The magnetic-reluctance object pattern 57 is equivalent to the magnetic-reluctance object pattern 22-3 of a magnetic resistance element 21, or 22-4.

[0043] When a coil 54 makes the alternation bias field of the same direction as internal magnetization of the magnetic-reluctance object pattern 56 impress, a coil 54 is wound in the same direction as internal magnetization of the magnetic-reluctance object pattern 56, and the coil 55 is wound in the same direction as internal magnetization of the magnetic-reluctance object pattern 57 so that a coil 55 may make the alternation bias field of the same direction as internal magnetization of the magnetic-reluctance object pattern 57 impress.

[0044] If a predetermined alternation current is passed by turns in coils 54 and 55, then, the alternating field which pass a predetermined alternation current in a coil 54, and are generated in it The alternating field which impress the alternation bias field of the internal magnetization direction to the magnetic-reluctance object pattern 56, pass a predetermined alternation current in a coil 55, and are generated in it It comes to impress the alternation bias field of the internal magnetization direction to the magnetic-reluctance object pattern 57, and the direction and strength of an external magnetic field helium of the same field as a magnetic resistance element 52 are detected.

[0045] In drawing 5 (a), the magnetic-reluctance sensor 61 comes to wind the coil 64 for alternation bias field impression around the magnetic-resistance-element package 63 which held the **** magnetic resistance element 62 which shows an outline to drawing 5 (b).

[0046] The barbershop pole mold magnetic-reluctance object pattern 65 of the direction where internal magnetization goes to the lower right from the upper left of drawing, and the barbershop pole mold magnetic-reluctance object pattern 66 of the direction where internal magnetization goes to the lower left from the upper right of drawing are formed in the magnetic resistance element 62 equivalent to the above-mentioned magnetic resistance element 21 at least. And when the magnetic-reluctance object pattern 65 is equivalent to the magnetic-reluctance object pattern 22-1 of a magnetic resistance element 21, or 22-2, the magnetic-reluctance object pattern 66 is equivalent to the magnetic-reluctance object pattern 22-3 of a magnetic resistance element 21, or 22-4.

[0047] The coil 64 is wound in the vertical direction of the magnetic-resistance-element package 63 in the direction 45 degrees to the internal magnetization direction of winding 65, i.e., a magnetic-reluctance object pattern, and the internal magnetization direction of the magnetic-reluctance object pattern 65.

[0048] Then, the alternating field which pass a predetermined alternation current in a coil 64, and are generated in it come to impress an alternation bias field to the magnetic-reluctance object patterns 65 and 66 in each internal magnetization direction, and the direction and strength of an external magnetic field helium of the same field as a magnetic resistance element 62 are detected.

[0049] However, there are both components of the direction of a bias field and the direction of an external magnetic field which should be detected in the field which passes an alternation current to a

coil 54, and 55 or 64, and is generated in it, and it becomes the output generated from a magnetic resistance element in the output at the time of bias field impression undetectable [an exact external magnetic field] including the bias field component of the direction of an external magnetic field.
[0050] Then, as shown for avoiding said un-arranging and detecting an exact external magnetic field at drawing 6 , zero field (electrical potential difference) time amount suitable between the changes of plus field (electrical potential difference) +Hb and minus field (electrical potential difference)-Hb is established, and change of the magnetic reluctance by the external magnetic field is detected at the time of the zero field.
[0051] That is, when the bias field of plus is impressed to a magnetic resistance element, for example, it is maintained at at least bias field at least 0:00 when internal magnetization of a magnetic-reluctance object pattern continues in the direction of a plus bias field component, and a set and its internal magnetization continue plus bias field impression. Then, the change in resistance of the magnetic-reluctance object pattern by the external magnetic field is measured in the condition at those bias field 0:00.
[0052] Subsequently, the bias field of minus is impressed to a magnetic resistance element, and magnetic-reluctance value change of the magnetic-reluctance object pattern by minus bias field impression is measured at bias field 0:00 following impression of the minus bias field. Consequently, exact measurement of an external magnetic field is enabled.
[0053] The explanatory view of the example of manufacture of the laminating mold magnetometric sensor according [drawing 7] to this invention, the example (the 1) of the spiral coil pattern for bias field impression according [drawing 8] to this invention, and drawing 9 are the examples (the 2) of the spiral coil pattern for bias field impression by this invention.
[0054] It sets to drawing 7 (a) and is SiO2 in an insulating substrate, for example, a front face. The conductor pattern 72-1 which uses a FOTORISO process and becomes some coils for bias field generating (lower layer section) is formed in the front face of Si substrate made to put or a glass substrate 71.
[0055] Subsequently, as shown in drawing 7 (b), after putting the insulating layer 73 which becomes with a resist, polyimide, or silicon nitride, as shown in the front face of the flat insulating layer 73 at drawing 7 (c), the magnetic-reluctance object pattern 76 which carried out the laminating of two or more conductor layers 75 which become withgold etc. is formed on the ferromagnetic pattern 74 which becomes in a permalloy etc.
[0056] Subsequently, a magnetic resistance element and the magnetic resistance element which carried out laminating formation of the coil for bias field generating are completed by forming the conductor pattern 72-2 which becomes some coils for bias field generating (management) on an insulating layer 77 as it is shown in drawing 7 (e), after putting the flattening insulating layer 77 which comes in SiN etc. on the insulating layer 73 in which the magnetic-reluctance object pattern 76 was formed as shown in drawing 7 (d), and the insulating protective coat 78.
[0057] However, you make it connect by the through hole (not shown) which penetrates an insulating layer 73 and an insulating layer 77, and a conductor pattern 72-1 and 72-2 constitute the coil for impressing an alternation bias field to the magnetic-reluctance object pattern 76 as a whole.
[0058] The circular spiral-like conductor pattern 82 is formed in the front face of the substrate 81 which becomes with glass etc. in drawing 8 . After covering a conductor pattern 82 by the insulating layer which is equivalent to said insulating layer 73 the appropriate back, The barbershop pole mold magnetic-reluctance object pattern 83-1 which is equivalent to the magnetic resistance element 22-1 for external magnetic field detection, for example, the magnetic-reluctance object pattern of drawing 2 , on the insulating layer, The barbershop pole mold magnetic-reluctance object pattern 83-2 equivalent to the magnetic-reluctance object pattern 22-2, The barbershop pole mold magnetic-reluctance object pattern 83-3 equivalent to the magnetic-reluctance object pattern 22-3, If the barbershop pole mold magnetic-reluctance object pattern 83-4 equivalent to the magnetic-reluctance object pattern 22-4 is formed and the magnetic-reluctance object pattern 83-1, 83-2, 83-3, and 83-4 are connected to for example, a full bridge, the magnetometric sensor by this invention will be completed.
[0059] In addition, since the bias field by the spiral-like conductor pattern 82 is hard flow mutually in the magnetic-reluctance object pattern 83-1, 83-2 and 83-3, and 83-4, the sense of the inclination conductor pattern formed in the magnetic-reluctance object pattern 83-1, 83-2 and 83-3, and 83-4 serves as this direction.
[0060] In this magnetometric sensor, if the terminal of the both ends of a conductor pattern 82 is

connected to AC power supply and the alternating current of predetermined ** is passed to a conductor pattern 82, the field of the direction which goes to the method of outside from the core of a conductor pattern 82, or its hard flow will occur in the perimeter of a conductor pattern 82, and the direction and strength of an external magnetic field helium will become it detectable like the magnetic resistance element 21 shown in drawing 2 .

[0061] In drawing 9 , the square shape spiral-like conductor pattern 92 is formed in the front face of the substrate 91 which becomes with glass etc. After covering a conductor pattern 92 by the insulating layer which is equivalent to said insulating layer 73 the appropriate back, The barbershop pole mold magnetic-reluctance object pattern 93-1 which is equivalent to the magnetic resistance element 22-1 for external magnetic field detection, for example, the magnetic-reluctance object pattern of drawing 2 , on the insulating layer, The barbershop pole mold magnetic-reluctance object pattern 93-2 equivalent to the magnetic-reluctance object pattern 22-2, The barbershop pole mold magnetic-reluctance object pattern 93-3 equivalent to the magnetic-reluctance object pattern 22-3, If the barbershop pole mold magnetic-reluctance object pattern 93-4 equivalent to the magnetic-reluctance object pattern 22-4 is formed and the magnetic-reluctance object pattern 93-1, 93-2, 93-3, and 93-4 are connected to for example, a full bridge, the magnetometric sensor by this invention will be completed.

[0062] In addition, since the bias field by the spiral-like conductor pattern 92 is hard flow mutually in the magnetic-reluctance object pattern 93-1, 93-2 and 93-3, and 93-4, the sense of the inclination conductor pattern formed in the magnetic-reluctance object pattern 93-1, 93-2 and 93-3, and 93-4 serves as this direction.

[0063] In this magnetometric sensor, if the terminal of the both ends of a conductor pattern 92 is connected to AC power supply and the alternating current of predetermined ** is passed to a conductor pattern 92, the field of the direction which goes to the method of outside from the core of a conductor pattern 92, or its hard flow will occur in the perimeter of a conductor pattern 92, and the direction and strength of an external magnetic field helium will become it detectable like the magnetic resistance element 21 shown in drawing 2 .

[0064] In addition, the alternation current passed to the spiral-like conductor patterns 82 and 92 will establish zero electrical-potential-difference time amount suitable between the changes of the ****** style explained using drawing 6 , i.e., positive voltage, and a minus electrical potential difference.

[0065]

[Effect of the Invention] As explained above, when the magnetometric sensor of this invention and the bias field impression approach were parallel to the magnetic-reluctance object pattern formation side, they enabled detection of measurable, for example, detection of earth magnetism, and presumed bearing from earth magnetism for the direction and magnetic field strength correctly to the feeble external magnetic field from arbitration.

[Translation done.]

(19)日本国特許庁（ＪＰ）　(12)公開特許公報（A）　(11)特許出願公開番号

特開平10－170619

(43)公開日　平成10年(1998)６月26日

(51)Int.Cl.[6]	識別記号	ＦＩ	
G01R 33/09		G01R 33/06	R
H01L 43/08		H01L 43/08	B

審査請求　未請求　請求項の数７　ＯＬ　（全９頁）

(21)出願番号　特願平8－326720

(22)出願日　平成８年(1996)12月６日

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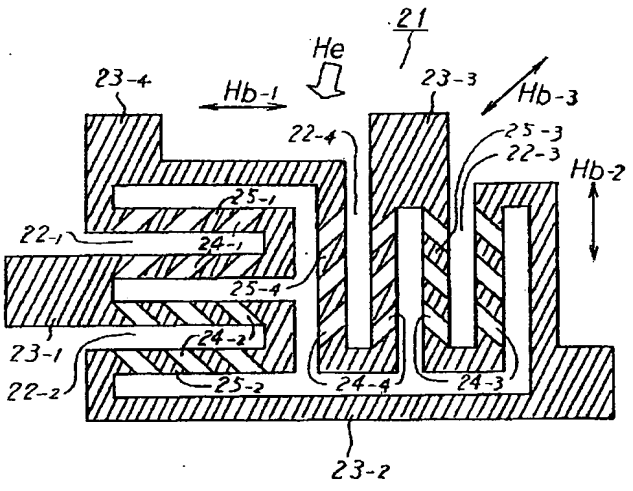
(54)【発明の名称】磁気センサとその交番バイアス磁界印加方法

(57)【要約】
【課題】　磁気センサとその磁気センサに交番バイアス磁界を印加する方法に関し、任意方向からの外部磁界に対しその方向と磁界強度を測定する。
【解決手段】　磁性膜パターン24-1～24-4に複数の導体層25-1～25-4が積層され、内部磁化方向が直交する少なくとも一対のバーバーポール型磁気抵抗体パターン22-1～22-4が設けられた磁気抵抗素子21と、磁気抵抗体パターン22-1～22-4のそれぞれの内部磁化方向に交番バイアス磁界Hb-1，Hb-2を印加する交番磁界印加手段を具えた磁気センサ。交番バイアス磁界Hb-1，Hb-2の印加に際し磁界方向の各切替え毎に零磁界時間を設けた交番バイアス磁界の印加方法。

本発明の実施例による磁気センサの磁気抵抗素子の説明図



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【特許請求の範囲】

【請求項１】　磁性膜パターンに複数の導体層が積層され、内部磁化方向が直交する少なくとも一対のバーバーポール型磁気抵抗体パターンが設けられた磁気抵抗素子と、該一対の磁気抵抗体パターンのそれぞれの内部磁化方向に交番バイアス磁界を印加する交番磁界印加手段、を備えたことを特徴とする磁気センサ。

【請求項２】　バーバーポール型の第１の磁気抵抗体パターンと、内部磁化方向が該第１の磁性体パターンと同一であって、磁性膜パターンに積層された複数の導体層の傾斜が該第１の磁性体パターンの導体層の傾斜に対し９０度をなすバーバーポール型の第２の磁気抵抗体パターンと、内部磁化方向が該第１の磁気抵抗体パターンの内部磁化方向に対し９０度をなすバーバーポール型の第３の磁気抵抗体パターンと、内部磁化方向が該第３の磁性体パターンと同一であって、磁性膜パターンに積層された複数の導体層の傾斜が該第３の磁性体パターンの導体層の傾斜に対し９０度をなすバーバーポール型の第４の磁気抵抗体パターンとが、フルブリッジに接続された磁気抵抗素子と、
該第１および第２の磁気抵抗体パターンの内部磁化方向に交番バイアス磁界を印加する第１の交番磁界発生手段と、
該第３および第４の磁気抵抗体パターンの内部磁化方向に交番バイアス磁界を印加する第２の交番磁界発生手段を備えたこと、
を特徴とする磁気センサ。

【請求項３】　バーバーポール型の第１の磁気抵抗体パターンと、内部磁化方向が該第１の磁性体パターンと同一であって、磁性膜パターンに積層された複数の導体層の傾斜が該第１の磁性体パターンの導体層の傾斜に対し９０度をなすバーバーポール型の第２の磁気抵抗体パターンと、内部磁化方向が該第１の磁気抵抗体パターンの内部磁化方向に対し９０度をなすバーバーポール型の第３の磁気抵抗体パターンと、内部磁化方向が該第３の磁性体パターンと同一であって、磁性膜パターンに積層された複数の導体層の傾斜が該第３の磁性体パターンの導体層の傾斜に対し９０度をなすバーバーポール型の第４の磁気抵抗体パターンとが、フルブリッジに接続された磁気抵抗素子と、
該第１～第４の磁気抵抗体パターンの内部磁化方向に対し約４５度の方向に交番バイアス磁界を印加する交番磁界発生手段を備えたこと、
を特徴とする磁気センサ。

【請求項４】　前記交番磁界発生手段が、前記磁気抵抗素子を収納したパッケージに巻回したコイルであること、
を特徴とする請求項１または２または３記載の磁気センサ。

【請求項５】　前記交番磁界発生手段が、絶縁基板上に

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導体パターンをスパイラル状に形成したコイルであること、
を特徴とする請求項１または２または３記載の磁気センサ。

【請求項６】　前記コイルと磁気抵抗素子およびパッケージが、絶縁基板上に積層し形成されてなること、
を特徴とする請求項４または５記載の磁気センサ。

【請求項７】　請求項１～３記載の磁気センサにおいて、前記交番バイアス磁界の印加に際し磁界方向の各切替え毎に零磁界時間を設けること、を特徴とする磁気センサの交番バイアス磁界印加方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、微小磁界の測定を可能にした磁気センサと、その磁気センサにおける交番バイアス磁界の印加方法に関する。

【０００２】地磁気レベルの微弱な磁界の方向と強さが正確に測定できると、地磁気または磁石からの磁界を計測し、センサが置かれている位置の方位や距離等を決定することができ、方位センサやポインティングデバイス等の広範な用途に応用できるようになる。

【０００３】

【従来の技術】図１０は磁性膜を使用した従来の磁気方位センサの説明図、図１１は図１０の磁気方位センサにおける抵抗変化特性の説明図である。

【０００４】図１０において、磁気方位センサに使用する磁気検出素子１は、Ｓｉ等にてなる基板上に、強磁性薄膜よりなる細長い磁気抵抗パターン２を折り返し状に形成し、その両端に導体端子３を形成してなる。

【０００５】磁気抵抗パターン２の長さ方向（内部磁化）に直交する外部磁界Ｈｅを検出する磁気検出素子１には、磁気抵抗パターン２の長さ方向に対し交差（望ましくは直交）方向に交番バイアス磁界Ｈｂを印加する。

【０００６】かかる磁気検出素子１において、作動のための所定電流を供給した磁気抵抗パターン２の内部磁化Ｍに直交方向の外部磁界Ｈｅが印加されたとき、その抵抗変化特性は、横軸を磁界強度Ｈ，横軸の原点を通る縦軸を磁気抵抗の変化量ΔＲとした図１１に示す如く、抵抗変化特性４は縦軸を対称軸とした山形形状である。

【０００７】そこで、交番バイアス磁界Ｈｂと作動電流ｉが印加された磁気検出素子１に、外部磁界Ｈｅが付与されたとき、プラスバイアスに対する磁界変化は
Ｈｂ→Ｈｂ＋Ｈｅ
となり、マイナスバイアスに対する磁界変化は
－Ｈｂ→－Ｈｂ＋Ｈｅ
となる。

【０００８】従って、プラスバイアスに対する磁界変化に伴う抵抗変化をδ_+とし、マイナスバイアスに対する磁界変化に伴う抵抗変化をδ_-とすると、磁気検出素子１を用いたセンサにおける抵抗変化量（出力）δは

$\delta = \delta_{-1} + \delta_{-2}$
となる。
【０００９】
【発明が解決しようとする課題】以上説明したように、図１０に示す抵抗変化特性をもった従来の磁気センサにおいて、外部磁界Ｈｅは交番バイアス磁界Ｈｂからの変動分として検出されるため、バイアス磁界Ｈｂの値が異なると同じ外部磁界Ｈｅに対して出力値が異なる場合があり、正確な測定ができないという問題点があった。
【００１０】一方、バーバーポール型磁気抵抗素子を用い、その素子の内部磁化と同方向に交番バイアス磁界を印加する磁界センサ（例えば特開平４－１９１６８５号）が知られている。
【００１１】図１２は内部磁化方向に交番バイアス磁界を印加する従来の磁界センサ用磁気抵抗素子の略式平面図であり、磁気抵抗素子５は、矢印で示す如く図の左右方向（左方向）に内部磁化Ｍ方向を揃えた、４個のバーバーポール型磁気抵抗体パターン6_{-1}～6_{-4}が形成され、それらの磁気抵抗体パターン6_{-1}～6_{-4}は接続端子7_{-1}～7_{-4}を介してフルブリッジに接続されている。
【００１２】かかる磁気抵抗素子５に、所定の作動電流（ｉ）および内部磁化Ｍと同方向の交番バイアス磁界Ｈｂを印加したとき、バイアス磁界Ｈｂの値に関わらず外部磁界Ｈｅを正確に測定できる。
【００１３】しかし、磁気抵抗素子５により測定される外部磁界Ｈｅは、磁気抵抗体パターン6_{-1}～6_{-4}の形成面に平行、かつ、内部磁化Ｍに直角方向の外部磁界Ｈｅのみを正確に測定する構成であり、任意方向からの外部磁界Ｈｅに対してその方向と磁界強度を測定できないという問題点がある。
【００１４】
【課題を解決するための手段】図１はバーバーポール型磁気抵抗体パターンとその抵抗変化特性の説明図であり、強磁性体パターン１２を形成し、その長さ方向（内部磁化Ｍ方向）に対し４５度の傾斜角度で等間隔の複数の導体層１３が積層された帯状の磁気抵抗体パターン１１において、内部磁化Ｍは強磁性体パターン１２の長さ方向を向き易く、特に外部磁界がない状態で内部磁化Ｍは、（ａ）図のように右向きまたは（ｂ）図のように左向きになっている。
【００１５】そして、磁気抵抗体パターン１１の幅方向、即ち内部磁化Ｍに直角方向の外部磁界Ｈｅを印加した場合、磁気抵抗体パターン１１の抵抗変化特性は、縦軸を磁気抵抗の変化量ΔＲ，ΔＲ＝０を通る横軸を磁界強度Ｈとした（ｃ）図に示す如く、内部磁化Ｍの向きによって傾斜が逆になる。
【００１６】即ち、例えば図１（ａ）に示す如く内部磁化Ｍが右向きのときの抵抗変化特性１４と、図１（ｂ）に示す如く内部磁化Ｍが左向きのときの抵抗変化特性１５は傾斜が逆であり、その内部磁化Ｍを反転させるには、反転させたい方向に数Ｏｅ以上の磁界を印加すればよいことが分かっている。
【００１７】そこで、内部磁化Ｍに直角方向の外部磁界Ｈｅを、図１（ａ）の磁気抵抗体パターン１１に印加したときの出力をＡとし、同一外部磁界Ｈｅを図１（ｂ）の磁気抵抗体パターン１１に印加したときの出力はＢとなり、内部磁化Ｍの向きを右向きと左向きに切替えると、外部磁界Ｈｅに対する出力は
Ａ＋Ｂ
となる。
【００１８】磁気抵抗体パターン１１の前記特性を利用し、従来技術の問題点を解決する本発明の第１の磁気センサは、磁性膜パターンに複数の導体層が積層され、内部磁化方向が直交する少なくとも一対のバーバーポール型磁気抵抗体パターンが設けられた磁気抵抗素子と、該一対の磁気抵抗体パターンのそれぞれの内部磁化方向に交番バイアス磁界を印加する交番磁界印加手段を備えたことを特徴とする。
【００１９】本発明の第２の磁気センサは、バーバーポール型の第１の磁気抵抗体パターンと、内部磁化方向が該第１の磁性体パターンと同一であって、磁性膜パターンに積層された複数の導体層の傾斜が該第１の磁性体パターンの導体層の傾斜に対し９０度をなすバーバーポール型の第２の磁気抵抗体パターンと、内部磁化方向が該第１の磁気抵抗体パターンの内部磁化方向に対し９０度をなすバーバーポール型の第３の磁気抵抗体パターンと、内部磁化方向が該第３の磁性体パターンと同一であって、磁性膜パターンに積層された複数の導体層の傾斜が該第３の磁性体パターンの導体層の傾斜に対し９０度をなすバーバーポール型の第４の磁気抵抗体パターンが、フルブリッジに接続された磁気抵抗素子と、該第１および第２の磁気抵抗体パターンの内部磁化方向に交番バイアス磁界を印加する第１の交番磁界発生手段と、該第３および第４の磁気抵抗体パターンの内部磁化方向に交番バイアス磁界を印加する第２の交番磁界発生手段を備えたことを特徴とする。
【００２０】本発明の第３の磁気センサは、バーバーポール型の第１の磁気抵抗体パターンと、内部磁化方向が該第１の磁性体パターンと同一であって、磁性膜パターンに積層された複数の導体層の傾斜が該第１の磁性体パターンの導体層の傾斜に対し９０度をなすバーバーポール型の第２の磁気抵抗体パターンと、内部磁化方向が該第１の磁気抵抗体パターンの内部磁化方向に対し９０度をなすバーバーポール型の第３の磁気抵抗体パターンと、内部磁化方向が該第３の磁性体パターンと同一であって、磁性膜パターンに積層された複数の導体層の傾斜が該第３の磁性体パターンの導体層の傾斜に対し９０度をなすバーバーポール型の第４の磁気抵抗体パターンが、フルブリッジに接続された磁気抵抗素子と、該第１～第４の磁気抵抗体パターンの内部磁化方向に対し約４

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５度の方向に交番バイアス磁界を印加する交番磁界発生手段を備えたことを特徴とする。

【００２１】本発明の第４の磁気センサは、前記本発明の第１～第３の磁気センサにおいて、前記交番磁界発生手段が、前記磁気抵抗素子を収納したパッケージに巻回したコイルである。

【００２２】本発明の第５の磁気センサは、前記本発明の第１～第３の磁気センサにおいて、前記交番磁界発生手段が、絶縁基板上に導体パターンをスパイラル状に形成したコイルである。

【００２３】本発明の第６の磁気センサは、前記本発明の第４または第５の磁気センサにおいて、前記コイルと磁気抵抗素子およびパッケージが、絶縁基板上に積層し形成されてなる。

【００２４】磁気抵抗体パターン１１の前記特性を利用し、従来技術の問題点を解決する本発明の磁気センサにおける交番バイアス磁界印加方法は、前記本発明の第１～第３の磁気センサにおいて、前記交番バイアス磁界の印加に際し磁界方向の各切替え毎に、零磁界時間を設けることである。

【００２５】前記本発明の第１の磁気センサは、内部磁化の方向が直交する少なくとも一対のバーバーポール型磁気抵抗体パターンを具え、その磁気抵抗体パターンのそれぞれの内部磁化方向に交番バイアス磁界を印加する。

【００２６】そこで、その一対の磁気抵抗体パターンに検出されるべき外部磁界が印加されると、一対の磁気抵抗体パターンには印加された外部磁界の内部磁化方向成分の強さに応じた出力を発生する。そのため、印加された該外部磁界の方向とその強さを検出可能にする。

【００２７】前記本発明の第２および第３の磁気センサは、２対の磁気抵抗体パターンフルブリッジ接続することで、入力電圧を共通として各磁気抵抗素子出力を得ることができる。

【００２８】前記本発明の第４および第５の磁気センサは、容易かつ簡易な交番バイアス磁界発生手段を提供するものである。前記本発明の第６の磁気センサは、本発明の第４および第５の磁気センサを小型化せしるものである。

【００２９】前記本発明の交番バイアス磁界印加方法は、磁界が印加されたとき磁気抵抗体パターンの内部磁化が印加磁界のバイアス磁界成分方向に揃い、そのあとでバイアス磁界零の状態でも内部磁化の向きは、バイアス磁界成分方向に揃ったままになる。その結果、一層正確な外部磁界の測定を可能にする。

【００３０】

【発明の実施の形態】図２は本発明の実施例による磁気センサの磁気抵抗素子の説明図、図３は本発明の実施例による磁気センサを備えた磁気検出装置の説明図、図４は交番バイアス磁界印加手段の第１の実施例の説明図、

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図５は交番バイアス磁界印加手段の第２の実施例の説明図、図６は本発明による交番バイアス磁界印加方法の説明図である。

【００３１】簡略した図２において、磁気抵抗素子２１は接続端子２３-１と２３-２と２３-３と２３-４を介して、バーバーポール型磁気抵抗体パターン２２-１と２２-２と２２-３と２２-４がフルブリッジ構成に接続されている。

【００３２】内部磁化が図の左右方向の磁気抵抗体パターン２２-１は、強磁性薄膜２４-１の上に形成した複数の導体層２５-１が、図の右上から左下方向に４５度傾斜するように形成されている。

【００３３】接続端子２３-１を介して磁気抵抗体パターン２２-１に接続し、内部磁化が磁気抵抗体パターン２２-１と同じ方向の磁気抵抗体パターン２２-２は、強磁性薄膜２４-２の上に形成した複数の導体層２５-２の傾斜が図の左上か右下方向に４５度、即ち導体層２５-１と２５-２が９０度をなすように形成されている。

【００３４】接続端子２３-２を介して磁気抵抗体パターン２２-２に接続し、内部磁化が図の上下方向の磁気抵抗体パターン２２-３は、強磁性薄膜２４-３の上に形成した複数の導体層２５-３が、図の左上から右下方向に４５度傾斜するように形成されている。

【００３５】接続端子２３-３を介して磁気抵抗体パターン２２-３に接続し、内部磁化が磁気抵抗体パターン２２-３と同じ方向の磁気抵抗体パターン２２-４は、強磁性薄膜２４-４の上に形成した複数の導体層２５-４の傾斜が図の右上から左下方向に４５度、即ち導体層２５-３と２５-４が９０度をなすように形成されている。

【００３６】そして、磁気抵抗体パターン２２-１と２２-４は、接続端子-４を介して接続されており、磁気抵抗体パターン２２-１と２２-２に印加する外部磁界検出用の交番バイアス磁界Ｈｂ-１が図の左右方向であるのに対し、磁気抵抗体パターン２２-１と２２-２に印加する外部磁界検出用の交番バイアス磁界Ｈｂ-２は、図の上下方向である。

【００３７】かかる磁気抵抗素子２１において、強磁性薄膜２４-１～２４-４を厚さ５００Å～２０００Åの８２％Ｎｉ－Ｆｅにて形成し、導体層２５-１～２５-４を厚さ５０００Åの金で形成したとき、内部磁化の反転は数Ｏｅ程度の磁界を印加させることで可能であり、磁気抵抗体パターン２２-１～２２-４の形成面に平行かつ任意方向からの外部磁界Ｈｅが印加されると、磁気抵抗体パターン２２-１～２２-４は、それぞれの内部磁化の方向の磁界成分の強さに応じた抵抗変化が生じ、その変化分を演算処理させることで、外部磁界Ｈｅの方向と強度を知ることができる。

【００３８】なお、磁気抵抗体パターン２２-１と２２-２と２２-３と２２-４の内部磁化の方向に４５度の交番バイアス磁界Ｈｂ-３は、磁気抵抗体パターン２２-１～２２-４の内部磁のＭ方向の成分をもつ。従って、交番バイアス

磁界Ｈｂ$_{-1}$とＨｂ$_{-2}$に変え交番バイアス磁界Ｈｂ$_{-3}$を印加させるようにしても、外部磁界Ｈｅの方向と強度を知ることができる。

【００３９】図３において、磁気検出装置３１の磁気抵抗素子２１には、駆動電源３２から接続端子２３$_{-1}$，２３$_{-2}$を介して作動電流を供給する。交番バイアス磁界発生手段をなす一対のコイル３３と３４は、同期検出用抵抗Ｒｓを介して交流電源３５に接続され、交流電源３５から所定周波数の交流電流を供給され、磁気抵抗素子２１に対して直交２方向の交番バイアス磁界Ｈｂ$_{-1}$とＨｂ$_{-2}$（図２参照）を印加する。

【００４０】磁気抵抗素子２１の出力端子となる接続端子２３$_{-1}$と２３$_{-2}$は、入力側結合コンデンサＣ$_{-1}$またはＣ$_{-2}$を介して、抵抗検出手段をなす交流増幅器３６に接続され、交流増幅器３６は出力側結合コンデンサ３７を介してアナログスイッチ３８の入力端子３９に接続され、アナログスイッチ３８の制御入力端子４０には、同期検出用抵抗Ｒｓの電圧が差動増幅器４１を介して増幅され入力される。

【００４１】アナログスイッチ３８の出力端子４２は、交番バイアス磁界の周波数成分の通過を素子するＲＣフィルタ４３を介して、出力端子４４に接続されている。図４（ａ）において磁気抵抗センサ５１は、図４（ｂ）に概略を示す如き磁気抵抗素子５２を収容した磁気抵抗素子パッケージ５３に、交番バイアス磁界印加用のコイル５４と５５を巻回してなる。

【００４２】前出の磁気抵抗素子２１に相当する磁気抵抗素子５２には、内部磁化が図の左右方向であるバーバーポール型磁気抵抗体パターン５６と、内部磁化が図の上下方向であるバーバーポール型磁気抵抗体パターン５７が少なくとも形成されており、磁気抵抗体パターン５６が磁気抵抗素子２１の磁気抵抗体パターン２２$_{-1}$または２２$_{-2}$に相当すると、磁気抵抗体パターン５７は、磁気抵抗素子２１の磁気抵抗体パターン２２$_{-3}$または２２$_{-4}$に相当する。

【００４３】コイル５４が磁気抵抗体パターン５６の内部磁化と同一方向の交番バイアス磁界を印加させるとき、コイル５５は磁気抵抗体パターン５７の内部磁化と同一方向の交番バイアス磁界を印加させるように、即ちコイル５４は磁気抵抗体パターン５６の内部磁化と同一方向に巻回され、コイル５５は磁気抵抗体パターン５７の内部磁化と同一方向に巻回されている。

【００４４】そこで、コイル５４と５５に交互に所定の交番電流を流すと、コイル５４に所定の交番電流を流して発生する交番磁界は、磁気抵抗体パターン５６にその内部磁化方向の交番バイアス磁界を印加し、コイル５５に所定の交番電流を流して発生する交番磁界は、磁気抵抗体パターン５７にその内部磁化方向の交番バイアス磁界を印加するようになり、磁気抵抗素子５２と同一面の外部磁界Ｈｅの方向と強さが検出される。

【００４５】図５（ａ）において磁気抵抗センサ６１は、図５（ｂ）に概略を示す如き磁気抵抗素子６２を収容した磁気抵抗素子パッケージ６３に、交番バイアス磁界印加用のコイル６４を巻回してなる。

【００４６】前出の磁気抵抗素子２１に相当する磁気抵抗素子６２には、内部磁化が図の左上から右下に向かう方向のバーバーポール型磁気抵抗体パターン６５と、内部磁化が図の右上から左下に向かう方向のバーバーポール型磁気抵抗体パターン６６が少なくとも形成されている。そして、磁気抵抗体パターン６５が磁気抵抗素子２１の磁気抵抗体パターン２２$_{-1}$または２２$_{-2}$に相当するとき、磁気抵抗体パターン６６は、磁気抵抗素子２１の磁気抵抗体パターン２２$_{-3}$または２２$_{-4}$に相当する。

【００４７】コイル６４は、磁気抵抗素子パッケージ６３の上下方向に巻回、即ち磁気抵抗体パターン６５の内部磁化方向と、磁気抵抗体パターン６５の内部磁化方向に対し４５度方向に巻回されている。

【００４８】そこで、コイル６４に所定の交番電流を流して発生する交番磁界は、磁気抵抗体パターン６５と６６に、それぞれの内部磁化方向に交番バイアス磁界を印加するようになり、磁気抵抗素子６２と同一面の外部磁界Ｈｅの方向と強さが検出される。

【００４９】しかし、コイル５４と５５または６４に交番電流を流して発生する磁界には、バイアス磁界方向と検出すべき外部磁界方向の両成分があり、バイアス磁界印加時の出力に磁気抵抗素子から発生する出力には、外部磁界方向のバイアス磁界成分を含み、正確な外部磁界の検出が不可能となる。

【００５０】そこで、前記不都合を回避し正確な外部磁界を検出するには図６に示す如く、プラス磁界（電圧）＋Ｈｂとマイナス磁界（電圧）－Ｈｂの切替え間に適当な零磁界（電圧）時間を設け、その零磁界時に外部磁界による磁気抵抗の変化を検出する。

【００５１】即ち、例えばプラスのバイアス磁界を磁気抵抗素子に印加したとき、磁気抵抗体パターンの内部磁化はそのプラスバイアス磁界成分方向に揃い、その内部磁化はプラスバイアス磁界印加に続くバイアス磁界零時でも維持される。そこで、そのバイアス磁界零時の状態で外部磁界による磁気抵抗体パターンの抵抗値変化を測定する。

【００５２】次いで、マイナスのバイアス磁界を磁気抵抗素子に印加し、そのマイナスバイアス磁界の印加に続くバイアス磁界零時に、マイナスバイアス磁界印加による磁気抵抗体パターンの磁気抵抗値変化を測定する。その結果、外部磁界の正確な測定を可能にする。

【００５３】図７は本発明による積層型磁気センサの製造例の説明図、図８は本発明によるバイアス磁界印加用スパイラルコイルパターンの実施例（その１）、図９は本発明によるバイアス磁界印加用スパイラルコイルパターンの実施例（その２）である。

【００５４】図７（ａ）において、絶縁基板例えば表面にＳｉO_2を被着させたＳｉ基板またはガラス基板７１の表面に、フォトリソプロセスを用いバイアス磁界発生用コイルの一部（下層部）となる導体パターン７２$_1$を形成する。

【００５５】次いで、図７（ｂ）に示す如く、レジストまたはポリイミドまたは窒化シリコン等にてなる絶縁層７３を被着したのち、平坦な絶縁層７３の表面に図７（ｃ）に示す如く、パーマロイ等にてなる強磁性体パターン７４の上に金等にてなる複数の導体層７５を積層した磁気抵抗体パターン７６を形成する。

【００５６】次いで、図７（ｄ）に示す如く磁気抵抗体パターン７６が形成された絶縁層７３の上に、ＳｉＮ等にてなる平坦化絶縁層７７を被着したのち、図７（ｅ）に示す如く、絶縁層７７の上にバイアス磁界発生用コイルの一部（上層部）となる導体パターン７２$_2$と、絶縁保護膜７８を形成し、磁気抵抗素子とバイアス磁界発生用コイルを積層形成した磁気抵抗素子が完成する。

【００５７】ただし、導体パターン７２$_1$と７２$_2$は、絶縁層７３と絶縁層７７を貫通するスルーホール（図示せず）によって接続せしめ、全体として磁気抵抗体パターン７６に交番バイアス磁界を印加するためのコイルを構成する。

【００５８】図８において、ガラス等にてなる基板８１の表面には、円形スパイラル状の導体パターン８２を形成する。しかるのち、前記絶縁層７３に相当する絶縁層で導体パターン８２を覆ったのち、その絶縁層の上に外部磁界検出用の磁気抵抗素子、例えば図２の磁気抵抗体パターン２２$_1$に相当するバーバーポール型磁気抵抗体パターン８３$_1$と、磁気抵抗体パターン２２$_2$に相当するバーバーポール型磁気抵抗体パターン８３$_2$と、磁気抵抗体パターン２２$_3$に相当するバーバーポール型磁気抵抗体パターン８３$_3$と、磁気抵抗体パターン２２$_4$に相当するバーバーポール型磁気抵抗体パターン８３$_4$を形成し、磁気抵抗体パターン８３$_1$，８３$_2$，８３$_3$，８３$_4$を例えばフルブリッジに接続させると、本発明による磁気センサが完成する。

【００５９】なお、スパイラル状の導体パターン８２によるバイアス磁界は、磁気抵抗体パターン８３$_1$と８３$_2$および８３$_3$と８３$_4$とで互いに逆方向なので、磁気抵抗体パターン８３$_1$と８３$_2$および８３$_3$と８３$_4$に形成する傾斜導体パターンの向きは同方向となる。

【００６０】かかる磁気センサにおいて、導体パターン８２の両端の端子を交流電源に接続し、導体パターン８２に所定の±の交流電流を流すと、導体パターン８２の周囲には、導体パターン８２の中心から外方に向かう方向またはその逆方向の磁界が発生し、図２に示す磁気抵抗素子２１と同様に、外部磁界Ｈｅの方向と強さが検出可能となる。

【００６１】図９において、ガラス等にてなる基板９１の表面には、角形スパイラル状の導体パターン９２を形成する。しかるのち、前記絶縁層７３に相当する絶縁層で導体パターン９２を覆ったのち、その絶縁層の上に外部磁界検出用の磁気抵抗素子、例えば図２の磁気抵抗体パターン２２$_1$に相当するバーバーポール型磁気抵抗体パターン９３$_1$と、磁気抵抗体パターン２２$_2$に相当するバーバーポール型磁気抵抗体パターン９３$_2$と、磁気抵抗体パターン２２$_3$に相当するバーバーポール型磁気抵抗体パターン９３$_3$と、磁気抵抗体パターン２２$_4$に相当するバーバーポール型磁気抵抗体パターン９３$_4$を形成し、磁気抵抗体パターン９３$_1$，９３$_2$，９３$_3$，９３$_4$を例えばフルブリッジに接続させると、本発明による磁気センサが完成する。

【００６２】なお、スパイラル状の導体パターン９２によるバイアス磁界は、磁気抵抗体パターン９３$_1$と９３$_2$および９３$_3$と９３$_4$とで互いに逆方向なので、磁気抵抗体パターン９３$_1$と９３$_2$および９３$_3$と９３$_4$に形成する傾斜導体パターンの向きは同方向となる。

【００６３】かかる磁気センサにおいて、導体パターン９２の両端の端子を交流電源に接続し、導体パターン９２に所定の±の交流電流を流すと、導体パターン９２の周囲には、導体パターン９２の中心から外方に向かう方向またはその逆方向の磁界が発生し、図２に示す磁気抵抗素子２１と同様に、外部磁界Ｈｅの方向と強さが検出可能となる。

【００６４】なお、スパイラル状の導体パターン８２および９２に流す交番電流は、図６を用いて説明した如き電流、即ちプラス電圧とマイナス電圧の切替え間に適当な零電圧時間を設けることになる。

【００６５】

【発明の効果】以上説明したように本発明の磁気センサおよびバイアス磁界印加方法は、磁気抵抗体パターン形成面に平行であれば、任意方向からの微弱な外部磁界に対してその方向と磁界強度を測定可能、例えば地磁気の検出，地磁気からの推定方位を正確に検知可能にした。

【図面の簡単な説明】

【図１】　バーバーポール型磁気抵抗体パターンとその抵抗変化特性の説明図

【図２】　本発明の実施例による磁気センサの磁気抵抗素子の説明図

【図３】　本発明の実施例による磁気センサを備えた磁気検出装置の説明図

【図４】　交番バイアス磁界印加手段の第１の実施例の説明図

【図５】　交番バイアス磁界印加手段の第２の実施例の説明図

【図６】　本発明による交番バイアス磁界印加方法の説明図

【図７】　本発明による積層型磁気センサの製造例の説明図

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【図８】　本発明によるバイアス磁界印加用スパイラルコイルパターンの実施例（その１）

【図９】　本発明によるバイアス磁界印加用スパイラルコイルパターンの実施例（その２）

【図１０】　磁性膜を使用した従来の磁気方位センサの説明図

【図１１】　図１０の磁気方位センサにおける抵抗変化特性の説明図

【図１２】　交番バイアス磁界を印加する従来の磁界センサ用磁気抵抗素子の略式平面図

【符号の説明】

１１，２２-１～２２-４，５６，５７，６５，６６，８３-１～８３-４，９３-１～９３-４　磁気抵抗体パターン

１２，７４　強磁性体パターン

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２４-１～２４-４　強磁性薄膜

１３，２５-１～２５-４，７５　導体層

２１，５２，６２　磁気抵抗素子

２３-１～２３-４　接続端子

３３，３４，５４，５５，６４，８２，９２　交番バイアス磁界発生手段をなすコイル

５１，６１　磁気抵抗センサ

５３，６３　磁気抵抗素子パッケージ

７１　基板

７２-１，７２-２　コイルの一部となる導体パターン

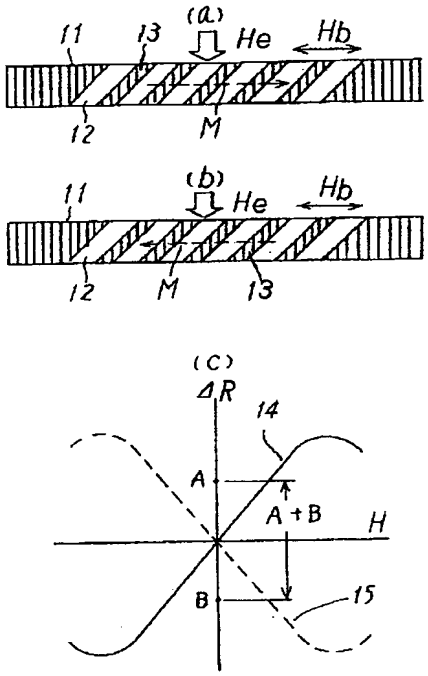
Ｍ　内部磁化

Ｈｂ　交番バイアス磁界

Ｈｅ　外部磁界

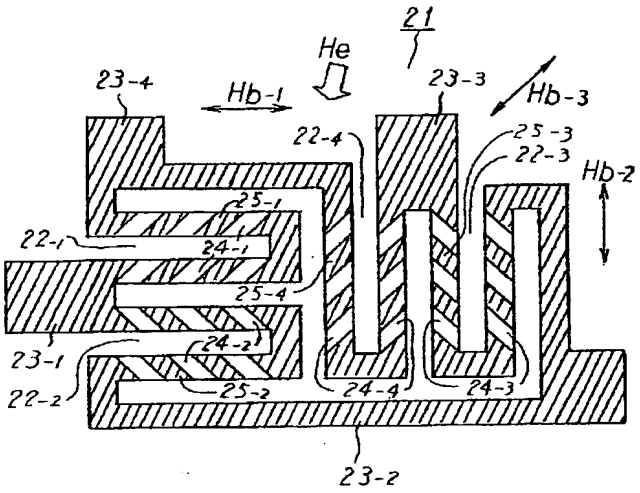
【図１】

バーバーポール型磁気抵抗体パターンとその抵抗変化特性の説明図



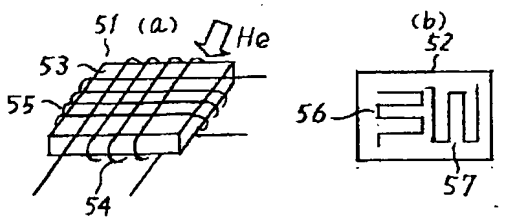
【図２】

本発明の実施例による磁気センサの磁気抵抗素子の説明図



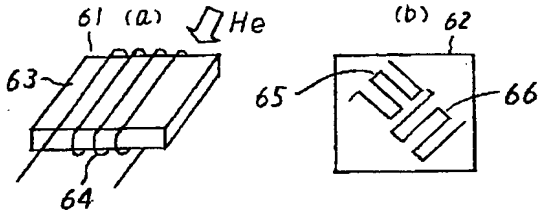
【図４】

交番バイアス磁界印加手段の第１の実施例の説明図



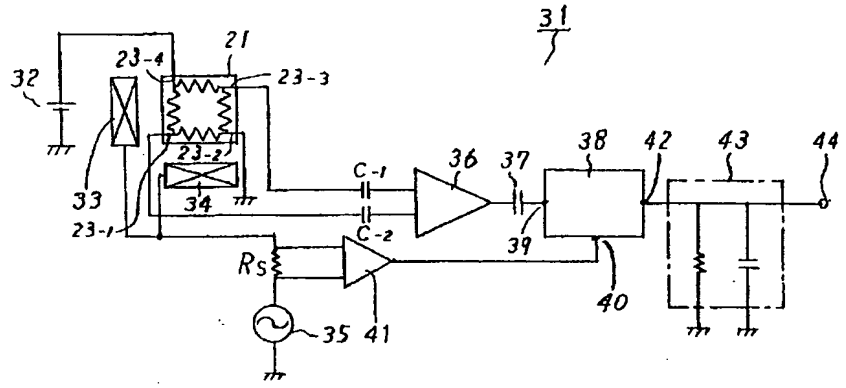
【図５】

交番バイアス磁界印加手段の第２の実施例の説明図



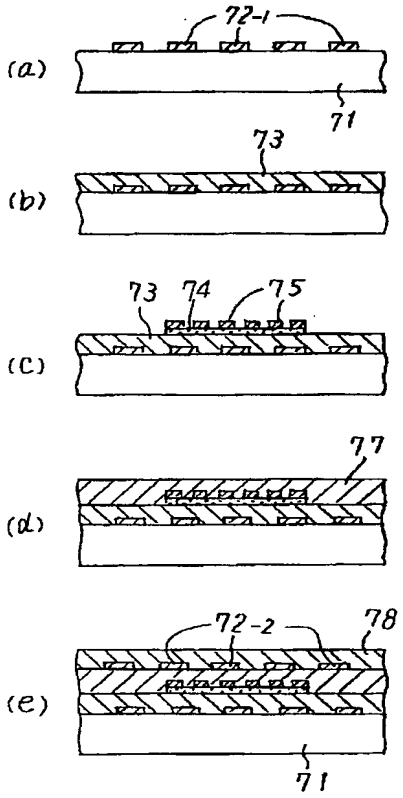
【図３】

本発明の実施例による磁気センサを備えた磁気検出装置の説明図



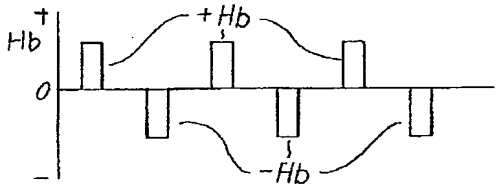
【図７】

本発明による積層型磁気センサの製造例の説明図



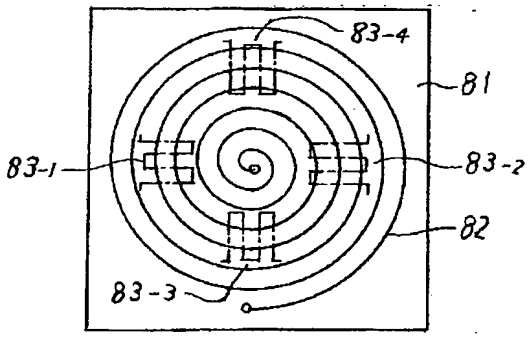
【図６】

本発明による交番バイアス磁界印加方法の説明図



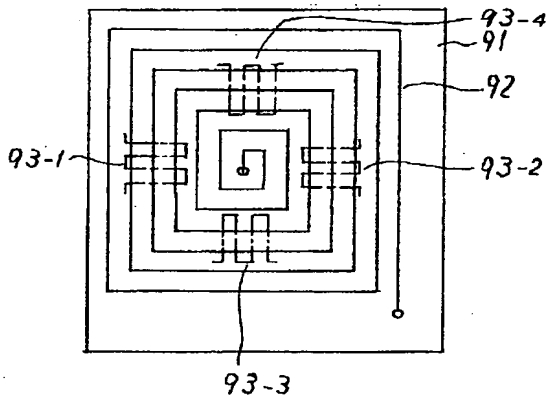
【図８】

本発明によるバイアス磁界印加用スパイラルコイル
パターンの実施例（その１）



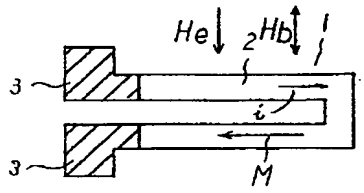
【図９】

本発明によるバイアス磁界印加用スパイラルコイル
パターンの実施例（その２）



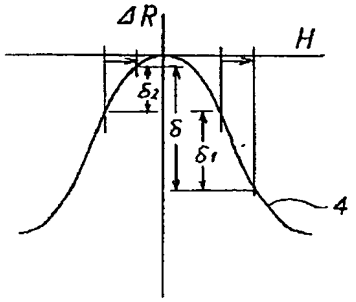
【図１０】

磁性膜を使用した従来の磁気方位センサの説明図



【図１１】

図１０の磁気方位センサにおける抵抗変化特性の説明図



【図１２】

交番バイアス磁界を印加する従来の磁界センサ用
磁気抵抗素子の略式平面図